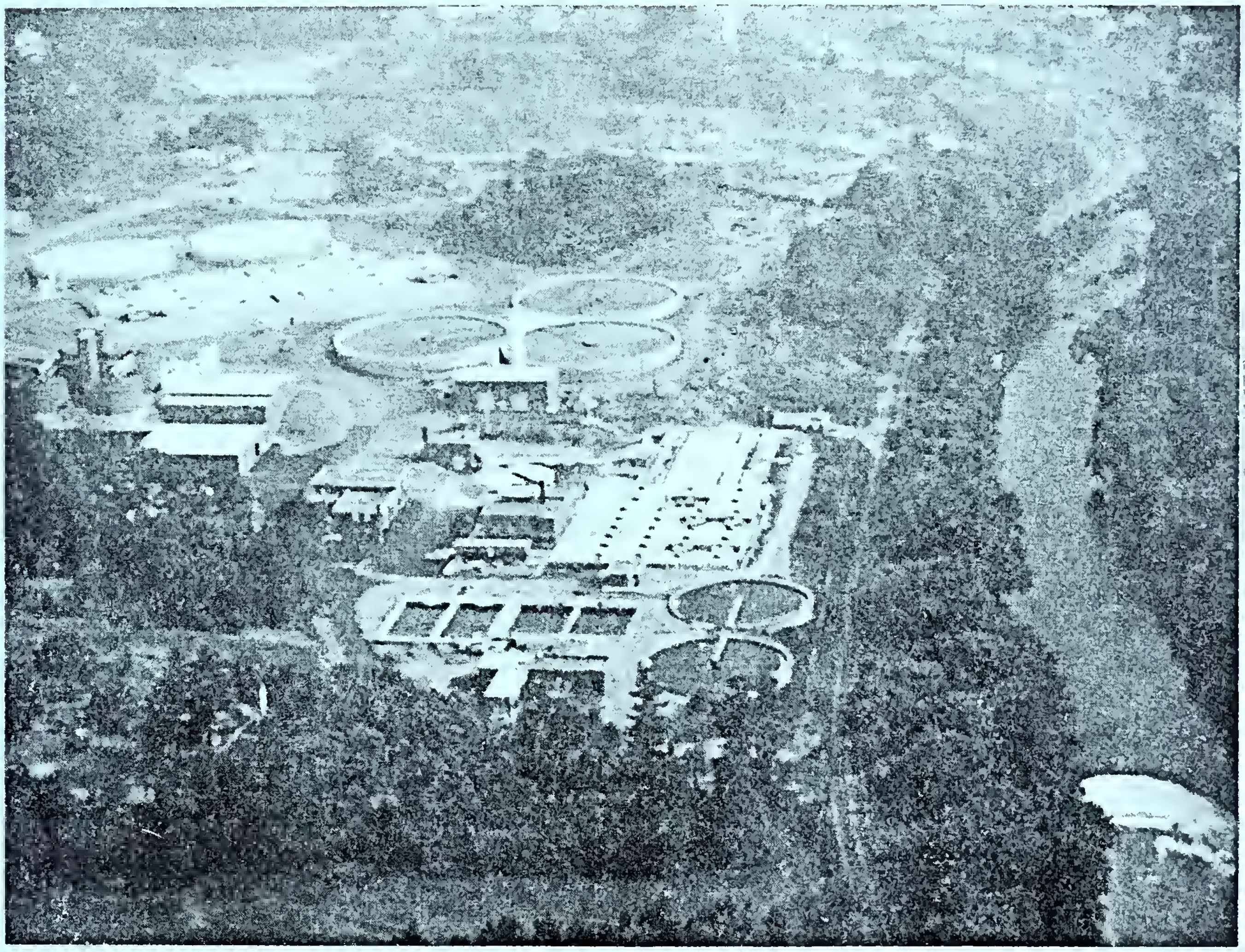
NUTRIENT LOADING STATUS OF THE CONESTOGA RIVER BASIN 1985 – 1989



SUSQUEHANNA RIVER BASIN COMMISSION

RESOURCE QUALITY MANAGEMENT & PROTECTION DIVISION

APRIL 1991

The Susquehanna River Basin Commission was created as an independent agency by a Federal-Interstate Compact* among the States of Maryland, New York, Commonwealth of Pennsylvania and the Federal Government. In creating the Commission, the Congress and State Legislatures formally recognized the water resources of the Susquehanna River basin as a regional asset vested with local, State and National interests for which all the parties share responsibility. As the single Federal-Interstate water resources agency with basinwide authority, the Commission's goal is to effect coordinated planning, conservation, management, utilization, development and control of basin water resources among the government and private sectors.

* Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December, 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).

COVER PHOTO - Lancaster Wastewater Treatment Facility, South Plant, Lancaster, Pennsylvania

NUTRIENT LOADING STATUS OF THE CONESTOGA RIVER BASIN, 1985-1989

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ABSTRACT

The Conestoga River at Conestoga, Pa., one of 14 Pennsylvania sites monitored by the Susquehanna River Basin Commission for its nutrient loading content from 1985 to 1989, was the only site to show a significant change in loading.

Annual nitrogen loads indicated a good relationship (no change in loading) with the mean annual stream discharge, while the phosphorus load for 1988 and 1989 showed a decreased loading.

Monthly base flow phosphorus concentrations were significantly lower during June 1988 to December 1989 than for the January 1985 to May 1988 period.

Records provided from the City of Lancaster, Pa. sewage treatment plant (STP) showed substantial reduction in phosphorus effluent loadings in 1988 and 1989 in contrast to the loadings of prior years.

Conestoga River phosphorus load reduction was similar to the STP phosphorus load reduction in 1988, but the STP reduction in 1989 accounted for only a part of the 1989 river reduction.

INTRODUCTION

The Susquehanna River Basin Commission, as a part of the Chesapeake Bay nutrient monitoring program, monitored baseflow and stormflow in the Conestoga River at Conestoga, Pa. and 13 other sites in the Susquehanna River basin during a five-year period from 1985 to 1989. Its 470 square mile basin is considered small in contrast to Marietta, Pa., the largest Susquehanna River Basin Commission monitored drainage area at 25,990 square miles. A primary purpose of this monitoring program is to establish a sound data base which can be used to effectively plan, implement, and evaluate immediate and long range reduction efforts. The Conestoga River data presents a prime example of how this information can be used.

MEASURED ANNUAL NITROGEN AND PHOSPHORUS LOADS TRANSPORTED BY THE CONESTOGA RIVER, 1985-1989

The measured annual nitrogen and phosphorus loads transported by the Conestoga River during the 1985-1989 period are presented in the following table.

TABLE 1. Annual Nutrient Loads, 1985-1989.

	1985	1986	1987	1988	1989
	thousands of pounds				
Nitrogen	7,830	11,530	9,825	10,780	13,660
Phosphorus	461	869	764	775	776

These values seem highly variable, probably because the nutrient loading of a river depends upon the amount of runoff it carries. It is, therefore, appropriate that data points be graphed by plotting the annual nutrient load versus its corresponding mean annual water discharge. If a close relationship exists, the assumption is made that significant changes have not occurred within the drainage basin to either increase or decrease the nutrient load. The resulting plot (Figure 1) shows a fairly good relationship between nitrogen load and stream discharge for the 1985 to 1989 period, whereas phosphorus (solid line) does not. The dashed line shows a good relationship for phosphorus 1985 through 1987 and shows that the 1988 and 1989 phosphorus values plot progressively further from the relationship line. This indicates that the phosphorus loads decreased for the same water discharge that carried higher phosphorus loads prior to 1988.

NUTRIENT CONCENTRATIONS DURING CONESTOGA RIVER BASEFLOW

Monthly baseflow nutrient concentrations were scanned to determine if a point source discharge impacted the stream and might, therefore, be responsible for the decreased phosphorus loading. The scan revealed that there was, in fact, a definite change in nutrient species concentration after May 1988. Monthly baseflow concentrations were averaged for the same months for the period January 1985 to May 1988 and the period June 1988 to December 1989. These data are listed in Table 2. Ortho, dissolved, and total phosphorus concentrations all show

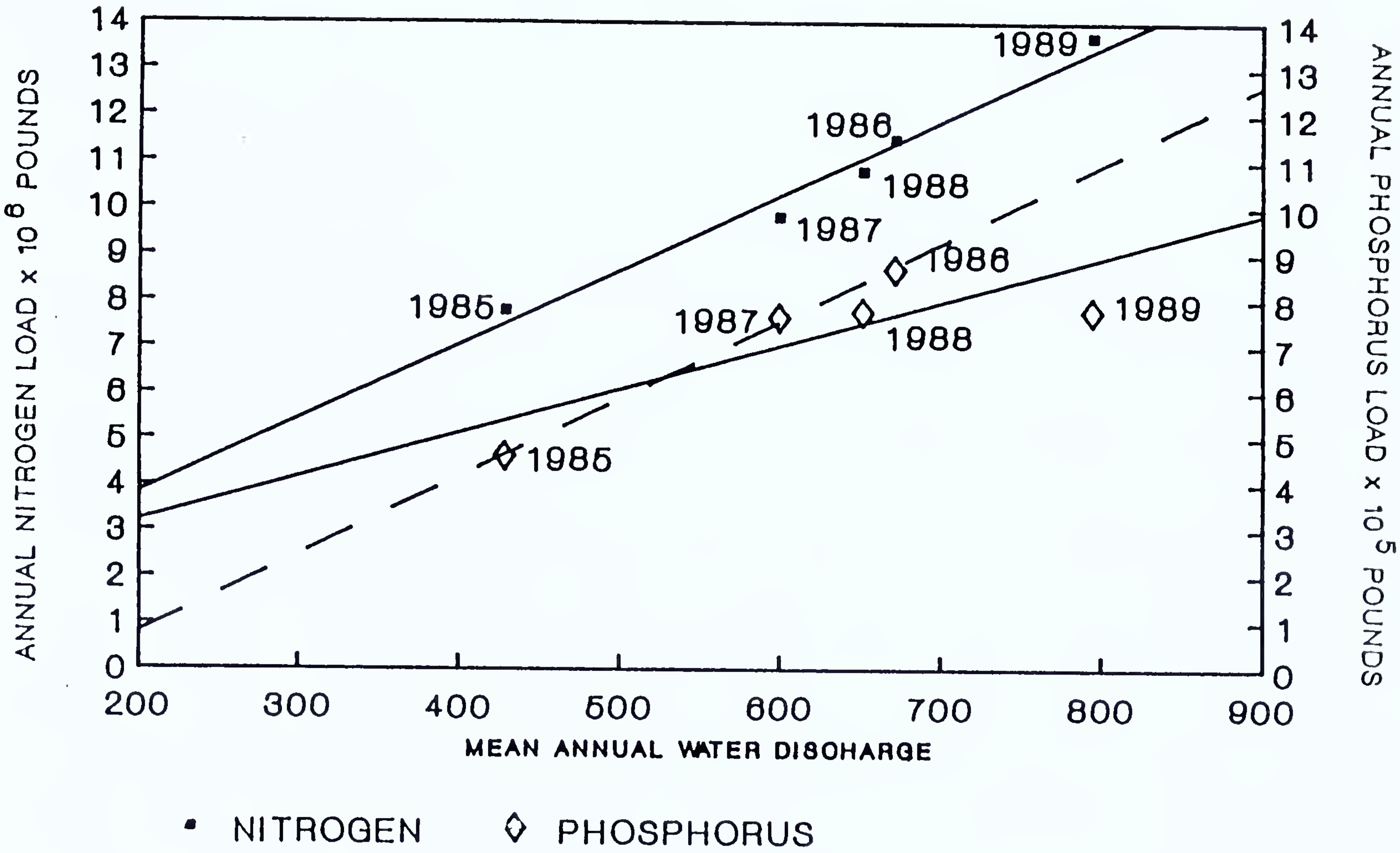

FIGURE 1. Conestoga River nitrogen and phosphorus loading, 1985-1989.

TABLE 2 Average Monthly Baseflow Nutrient Concentrations Conestoga River at Conestoga, Pennsylvania, January 1985-May 1988 and June 1988-December 1989

Month	Ortho Phosphorus 85-88	Ortho Phosphorus 88-89	Dissolved Phosphorus 85-88	Dissolved Phosphorus 88-89	Total Phosphorus 85-88	Total Phosphorus 88-89
	mg/l					
January	0.15	0.13	0.23	0.15	0.30	0.18
February	.22	.07	.23	.14	.25	.18
March	.10	.09	.18	.14	.23	.21
April	.15	.10	.18	.12	.23	.16
May	.22	.05	.23	.13	.25	.16
June	.33	.11	.30	.13	.40	.27
July	.37	.10	.42	.17	.55	.27
August	.30	.21	.48	.24	.55	.30
September	.23	.20	.40	.24	.50	.27
October	.32	.20	.36	.26	.48	.27
November	.26	.15	.36	.20	.45	.23
December	.07	.15	.25	.18	.28	.20
Mean	.21	.12	.27	.16	.34	.21

Month	Total Ammonia Nitrogen 85-88	Total Ammonia Nitrogen 88-89	Total Nitrate Plus Nitrite Nitrogen 85-88	Total Nitrate Plus Nitrite Nitrogen 88-89	Total Organic Nitrogen 85-88	Total Organic Nitrogen 88-89
	mg/l					
January	0.65	0.05	8.90	8.00	0.85	0.30
February	.60	.07	8.00	8.20	.85	.35
March	.34	.04	8.60	8.60	.70	.50
April	.32	.02	7.80	8.40	1.10	.50
May	.23	.04	7.70	8.40	1.05	.40
June	.11	.04	7.40	8.50	.65	.90
July	.06	.03	7.40	7.40	.80	1.00
August	.13	.05	5.80	9.50	.90	.40
September	.08	.06	7.00	8.60	.70	.70
October	.17	.10	8.20	8.20	.80	.55
November	.30	.09	8.00	6.90	.70	.40
December	.50	.09	8.80	9.20	.65	.40
Mean	.33	.06	7.90	8.30	.81	.53

significant decreases in the June 1988 to December 1989 period over the January 1985 to May 1988 period. A significant decrease between the same periods can also be seen in total ammonia nitrogen but the nitrogen decrease is offset due to the concurrent increase in nitrate-nitrogen, most likely due to the oxidation of ammonia to nitrate nitrogen (nitrification). A decrease in concentration is also exhibited by organic nitrogen.

LANCASTER CITY SEWAGE TREATMENT PLANT ANNUAL PHOSPHORUS LOADING, 1985-1989

The five years of annual nitrogen loading indicated a stable relationship with mean annual water discharge, while the phosphorus stability disintegrated beginning in 1988. The abrupt changes found during baseflow conditions (May 1988) in the concentrations of the nitrogen species and phosphorus suggests the influence of a large sewage treatment plant (STP). Contact was made with the Superintendent of Wastewater Operations for the City of Lancaster, Pa., William G. Horst, who pointed out that the City had recently built a new STP. In addition, he and John Troutman, head of the Wastewater Laboratory, provided treatment plant monthly effluent records for 1985 through the present, which showed a dramatic decrease in phosphorus and ammonia concentrations from May 1988 to the present time.

The summarized STP phosphorus data is included in Table 3 and indicates that the STP phosphorus output decreased in 1988 and 1989. Several interesting points can be seen from these data. First, 64 percent of the Conestoga River phosphorus load for 1985 came from STP effluent. The reason for this high

percent is twofold--1985 had the highest STP phosphorus discharge for the five-year period and at the same time the stream experienced the lowest (73 percent of the long-term annual discharge) annual stream discharge. Second, there was a dramatic decrease in the STP phosphorus output in 1989, the first full year for the new plant being in compliance. This should have reduced the measured load. It did not, probably because it was also a very wet year--the highest annual streamflow (136 percent of the long-term average annual flow) of the five-year period. The data in Table 3 indicate that while the phosphorus output from the STP has been decreasing dramatically, the total phosphorus loads for 1987-1989 remain similar. This is probably due to the offset induced by a continuously increasing mean annual stream discharge since 1987.

In order to determine the effect the Lancaster STP output reduction had on the basin load, an average annual phosphorus load for 1985-1987 of 236,000 pounds from the STP was calculated. By subtracting the 1988 and 1989 STP output of 172,000 and 94,000 pounds respectively from the Lancaster STP average phosphorus output, a decrease or reduction of 64,000 and 142,000 pounds of phosphorus for 1988 and 1989 is obtained. If these precompliance STP output values are added to the measured loads of 776,000 and 777,000 for 1988 and 1989, respectively, they result in hypothetical loads of 840,000 and 919,000 pounds phosphorus (Figure 2). The 1988 load of 840,000 plots on top of the 1985-1987 regression line and implies that the STP was solely accountable for the phosphorus decrease; however, the 919,000

TABLE 3. Annual Phosphorus Loading for Conestoga River Basin, 1985-1989

Year	Total Load	*STP Output	Nonpoint Load	STP Output / Total Load	**Mean Annual Stream Flow
	pounds			percent	
1985	461,000	294,000	167,000	64	73
1986	869,000	229,000	640,000	26	115
1987	764,000	244,000	520,000	32	102
1988	776,000	192,000	584,000	25	111
1989	777,000	114,000	663,000	15	136

* Includes 20,000 pounds phosphorus annually from Ephrata and Lititz STPs

** Mean annual water discharge relative to long-term average annual water discharge

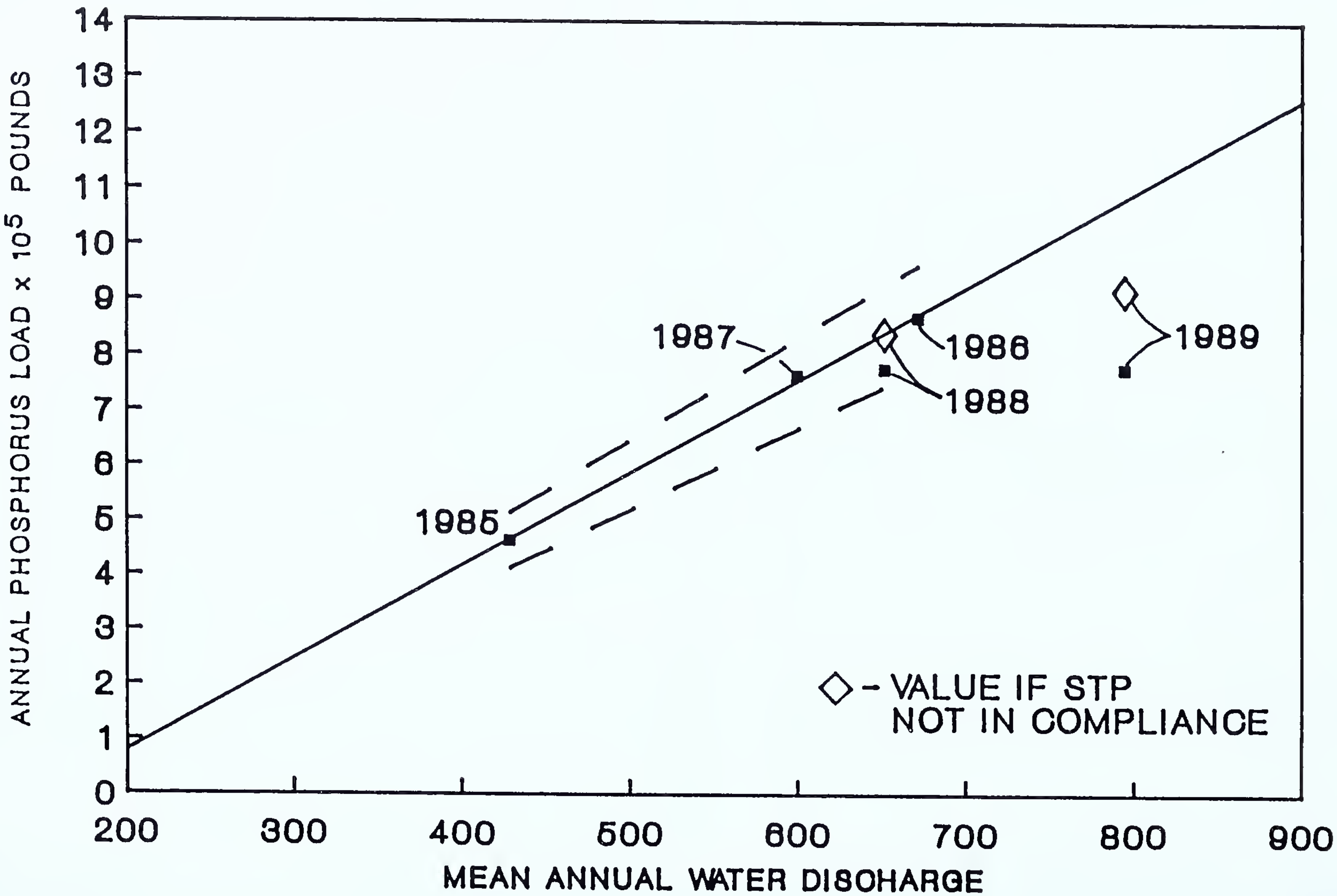

FIGURE 2. Conestoga River phosphorus loading, 1985–1989.

load for 1989 appears slightly below the 11 percent average error boundary and implies that additional reduction measures may have been in force.

ANNUAL NONPOINT SOURCE PHOSPHORUS LOADING, 1985-1989

An additional consideration is to evaluate the nonpoint source phosphorus load--stream discharge relationship. This is presented in Figure 3. A strong linear relation is seen between the nonpoint loads for 1985-1988 and discharge but, as in the case with the total load, breaks down in 1989. Since it is well known that there is a strong chemical affinity between phosphorus and secondary clay minerals and organic matter, there should be a relationship between sediment and phosphorus. In order to confirm this, annual sediment loads were plotted against their corresponding water discharge (Figure 4) to see if it would help explain the 1989 phosphorus load reduction. Although the plot contains substantial scatter, it does indicate that the 1989 sediment load is well below that expected for the corresponding water discharge. The factors causing the decrease in the sediment load need to be explored.

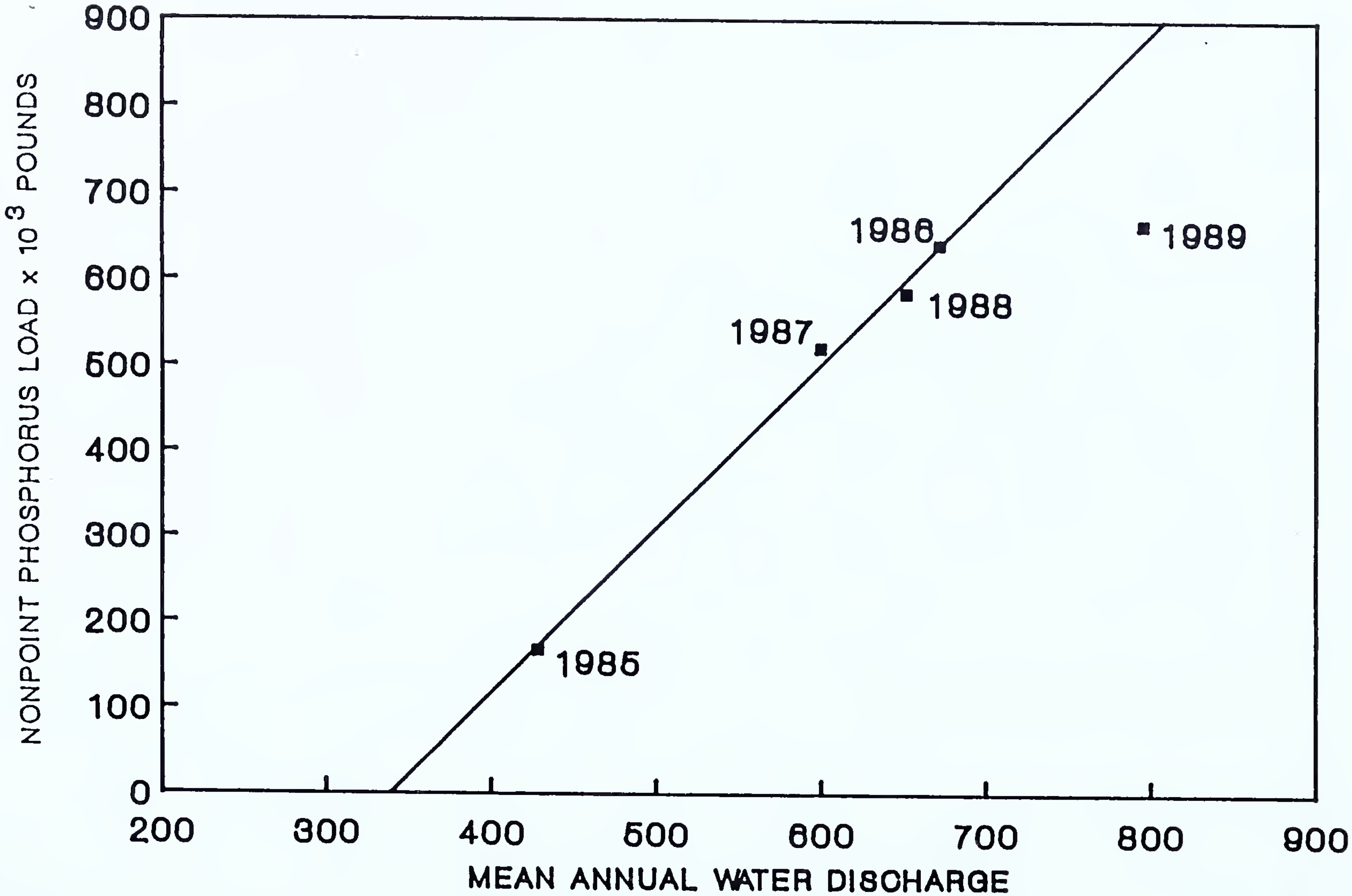

FIGURE 3. Conestoga River nonpoint source phosphorus loading, 1985-1989.

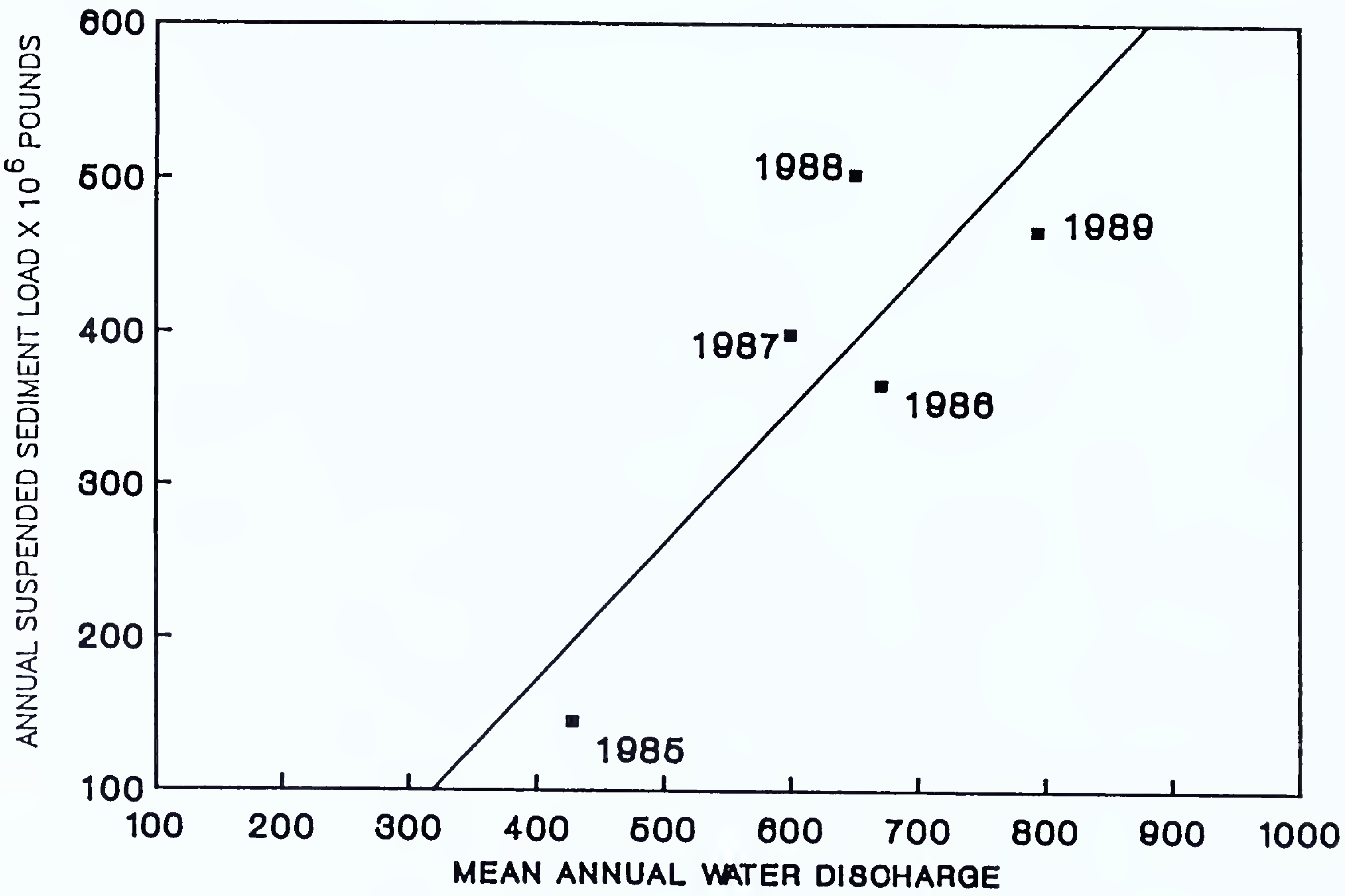

FIGURE 4. Conestoga River sediment loading, 1985-1989.

SUMMARY AND CONCLUSIONS

Nutrient monitoring of the Conestoga River has indicted no change in the nitrogen loading for the period 1985-1989, but shows a slight decrease in the phosphorus load for 1988 and a significant decrease for 1989.

Records from the Lancaster STP show a decreased phosphorus concentration in their effluent midway through 1988 and an even lower concentration throughout 1989. While they have significantly decreased their ammonia concentration during the same period, the nitrate concentration has concurrently increased.

Subtraction of the point source STP nutrient output from the measured basin load provides an estimate of the nonpoint source nutrient load. Evaluation of this phosphorus load with water discharge shows no change in loading from 1985-1988, but shows a definite load decrease in 1989. This decrease in 1989 phosphorus nonpoint source load is shown to be coincidental with the lower than normal suspended sediment load in 1989.

This report indicates that long-term monitoring data can be used to detect changes in small tributary watersheds. However, interpretation of the data must be coupled with a knowledge of the changing conditions within the watershed.